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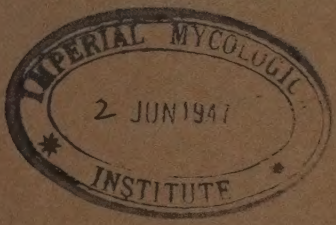

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MATHÉMATIQUES

SUR LES GROUPES p-DÉCOMPOSABLES

Par IRÈNE TCHOUNIKHIN et S. A. TCHOUNIKHIN

(Présenté par O. J. Schmidt, de l'Académie, le 27.XII. 1942)

1. L'objet de l'article présent font les groupes dits décomposables, présentant une des généralisations possibles des groupes spéciaux. On apprend que plusieurs propriétés caractéristiques des groupes spéciaux s'étendent aux groupes p-décomposables. Les résultats de ces études sont aussi appliqués à la détermination de la forme et du nombre de sous-groupes non-spéciaux de groupes finis. On établit qu'à tout groupe non-spécial de Silow se joint un groupe non-spécial d'une certaine forme et que tous ces sous-groupes sont non-isomorphes. L'exception n'a lieu que pour trois types de groupes.

2. Dans cette étude nous employons une formule obtenue par S. A. Tchounikhin (1) donnant la transformation d'un groupe $\mathfrak{G}$ dans le groupe complémentaire abélien $\mathfrak{H}/\mathfrak{K}$, où $\mathfrak{H}$ est un sous-groupe de $\mathfrak{G}$, $\mathfrak{K}$ — le commutant de $\mathfrak{H}$ ou bien un sous-groupe contenant le commutant de $\mathfrak{H}$; cette formule est

$$|A| = A^{a_1} D_2 A^{a_2} D_2^{-1} \dots D_s A^{a_s} D_s^{-1} \mathfrak{K}$$

où A désigne un élément quelconque de $\mathfrak{G}$ et $|A|$ — son image dans $\mathfrak{H}/\mathfrak{K}$.

3. Nous introduisons des notations suivantes:

1) Par un pd-groupe (pd-sous-groupe) nous désignons tout groupe (sous-groupe) dont l'ordre est divisible par le nombre premier donné p.

2) Un pd-groupe sera dit p-décomposable s'il se décompose en produit direct de deux facteurs dont l'un est son sous-groupe de Silow appartenant au nombre p. En particulier, les p-groupes mêmes seront regardés comme p-décomposables.

3) Groupes du type S (2) sont des groupes non-spéciaux dont tous les sous-groupes sont spéciaux *. On sait (2) que l'ordre de tels groupes n'est divisible que par deux nombres premiers différents; le sous-groupe de Silow appartenant à l'un d'eux est cyclique, celui appartenant à l'autre est invariant **.

4) Groupe du type S_1 c'est un groupe dont l'ordre n'est divisible que par deux nombres premiers différents et qui ne contient, à l'égard de l'isomorphie, qu'un seul type de sous-groupes non-spéciaux propres. Un des sous-groupes de Silow est invariant, l'autre est cyclique.

---

* Un groupe est désigné comme spécial s'il est le produit direct de tous ses sous-groupes de Silow des ordres différents.

** Cette désignation est due à S. A. Tchounikhin. Pour les détails sur les groupes du type S voir (2).

5) Groupe du type S_2 c'est un groupe dont l'ordre n'est formé que par trois nombres premiers différents, donc est $p^\alpha q^\beta r^\gamma$, et qui ne contient, à l'égard de l'isomorphie, que deux types de sous-groupes non-spéciaux propres. Le sous-groupe de Silow d'ordre p^α est cyclique; il y a un sous-groupe invariant $\mathfrak{N}$ d'ordre $q^\beta r^\gamma$, deux cas étant possibles:

a) $\mathfrak{N}$ est un groupe spécial; ils existent des sous-groupes d'ordre $p^\alpha q^\beta$ et d'ordre $p^\alpha r^\gamma$;

b) $\mathfrak{N}$ est du type S; il existe encore un sous-groupe du type S, dont l'ordre est divisible par p^α et relativement premier à son indice.

6) Groupe du type Z_p c'est un *pd*-groupe p-indécomposable dont tous les *pd*-sous-groupes sont déja p-décomposables.

7) Soit $m = q_1^{\alpha_1} q_2^{\alpha_2} \dots q_k^{\alpha_k}$ la décomposition en facteurs premiers du plus grand diviseur commun m de deux nombres naturels n_1 et n_2. Introduisons le symbole $T(n_1, n_2)$, égal à 1 pour $m = 1$ et à

$$\prod_q (q^\alpha - 1) \cdot (q^{\alpha-1} - 1) \dots (q - 1)$$

pour $m > 1$.

8) Nous dirons que le diviseur premier p de l'ordre du groupe $\mathfrak{G}$ est p-o l a r i s é au moyen du nombre naturel k, s'il existe la série de sous-groupes invariants

$$\mathfrak{G} = \mathfrak{N}_0 \supset \mathfrak{N}_1 \supset \mathfrak{N}_2 \supset \dots \supset \mathfrak{N}_l = E$$

du groupe $\mathfrak{G}$ telle que pour tout i le nombre $T(n_{i-1}/n_i, k)$ est relativement prime avec d_i, d_i étant le plus grand diviseur commun de p et de l'ordre du groupe $\mathfrak{G}/\mathfrak{N}_i$ et n_i étant l'ordre de $\mathfrak{N}_i$.

4. Nous avons obtenu les théorèmes suivants dont les démonstrations détaillées seront publiées dans un autre journal.

Théorème I. *Les groupes du type Z_p et du type S coïncident.*

Théorème II. *Un pd-groupe n'appartenant pas au type S est p-décomposable si et seulement s'il ne contient pas de pd-sous-groupes du type S.*

Théorème III. *Tout pd-groupe p-indécomposable contient toujours un pd-sous-groupe du type S ou bien lui-même est de ce type.*

Théorème IV. *Si l'ordre d'un groupe n'est divisible que par k nombres premiers différents et ce groupe est indécomposable par rapport à chacun d'eux, il correspond alors à tout diviseur p_α de l'ordre du groupe un p_αd-sous-groupe p_α-indécomposable propre, et tous ces k-sous-groupes sont non-isomorphes deux-à-deux. L'exception n'a lieu que pour les groupes de types S, S_1, S_2.*

Théorème V. *La quantité de facteurs premiers différents de l'ordre d'un groupe par rapport auxquels ce groupe est indécomposable ne peut pas être égale à un.*

Théorème VI. *Si l'ordre du groupe $\mathfrak{G}$ égale ab, $(a, b) = 1$, et si k est le nombre de tous les diviseurs premiers divers de a, et $\tau(b)$ est le nombre de tous les diviseurs premiers divers de b, si enfin le groupe est indécomposable par rapport à tout diviseur premier p_α de a et décomposable par rapport à tout diviseur premier q_β de b, alors à chacun de tels p_α correspond $\tau(b)$ p_αd-sous-groupes p_α-indécomposables propres de $\mathfrak{G}$, et tous ces $k\tau(b)$ sous-groupes sont non-isomorphes deux-à-deux. L'exception a lieu dans les cas où le sous-groupe d'ordre a contenu dans $\mathfrak{G}$ est d'un des types S, S_1, S_2.*

Théorème VII. *Soit $\mathfrak{G}$ un groupe d'ordre $p^\rho n$, $(p, n) = 1$, p étant un nombre premier, et soit $p^\sigma m$, $(p, m) = 1$, $\rho \geqslant 0$, l'ordre du commutant de $\mathfrak{G}$. Pour que $\mathfrak{G}$ soit p-décomposable, il est nécessaire et suffisant que tout diviseur premier de l'ordre de $\mathfrak{G}$ différent de p soit polarisé par le nombre p^ρ et que p lui-même soit polarisé par m.*

Théorème VIII. *Pour que $\mathfrak{G}$ soit p-décomposable, il faut et il suffit qu'il existe une série de sous-groupes invariants de $\mathfrak{G}$*

$$\mathfrak{G} = \mathfrak{N}_0 \supset \mathfrak{N}_1 \supset \mathfrak{N}_2 \supset \dots \supset \mathfrak{N}_l = E$$

telle que pour chacun de ses groupes complémentaires $\mathfrak{N}_{i-1}/\mathfrak{N}_i$ *deux conditions suivantes soient remplies:*

1) *Tout élément de* $\mathfrak{N}_{i-1}/\mathfrak{N}_i$ *dont l'ordre est une puissance de p doit être permutable avec tout élément de* $\mathfrak{G}/\mathfrak{N}_i$ *dont l'ordre n'est pas divisible par p.*

2) *Tout élément de* $\mathfrak{N}_{i-1}/\mathfrak{N}_i$ *dont l'ordre ne se divise pas par p doit être permutable avec tout élément de* $\mathfrak{G}/\mathfrak{N}_i$ *dont l'ordre est une puissance de p.*

Théorème IX. *Pour qu'un groupe* $\mathfrak{G}$ *d'ordre* $p^\lambda n$, $(p, n) = 1$, *soit p-décomposable, il faut et il suffit que* $\mathfrak{G}$ *contienne deux séries compositionnelles, telles que* λ *premiers indices de l'un et* λ *derniers indices de l'autre soient égals à p.*

On doit noter particulièrement la démonstration du théorème IV distinguée par son étendue et par son originalité. Dans la présente communication courte on peut seulement dire que pour cela les auteurs ont introduit la notion de «l'orientation» de sous-groupes du type S et construisirent ensuite des chaines spéciales de tels sous-groupes—«chaînes régulières» et «chaînes au noyau».

Institut Electromécanique des
Ingénieurs de chemin de fer.

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PHYSICS

ON PROPAGATION OF SOUND WAVES IN EDDYING FLOW

By A. M. OBUKHOV

(Communicated by O. J. Schmidt, Member of the Academy, 28. XII. 1942)

In a paper by Andreev and Russakov (1) certain problems of wave acoustics of a medium in motion are solved on the basis of equations obtained for the case of a potential field of velocities. However, in the most interesting cases, from a practical point of view, such as the propagation of sound in a turbulent atmosphere, one has to deal with an eddying flow which, strictly speaking, does not come under the scope of the equation derived in the above-mentioned paper.

In the present note approximate equations are derived for the acoustics of an eddying flow.

The equations of acoustics can be obtained from the general equation of hydrodynamics of a compressible fluid by means of the superposition of small disturbances upon the main flow.

Let us adopt the following hypotheses.

1) The velocity field of the main flow is incompressible:

$$\operatorname{div} \vec{v}_0 = 0. \tag{1}$$

2) The values of velocity in the main flow are small in comparison with the velocity of sound.

The «dimensionless velocity of the flow»

$$\frac{v_0}{c} = u \tag{2}$$

is taken to be a small magnitude of order one.

3) The main flow is supposed to be quasi-stationary. The variation of the elements of the main flow within an interval of time comparable to the oscillations of the sound field is negligibly small.

4) The intensity of the vortices of the main flow is a small magnitude of order one in comparison with the angular frequency of the sound wave.

5) Changes in sound velocity are small, owing to temperature non-uniformity of the medium.

$$|\operatorname{grad} \lg c^2| \lambda \ll 1. \tag{3}$$

Introducing the potential of pressure

$$\Pi = \int \frac{dp}{\rho}, \tag{4}$$

one may write the equations of hydrodynamics for an ideal compressible fluid in the following form:

$$\frac{\partial \vec{v}}{\partial t} + [\vec{\Omega}, \vec{v}] + \operatorname{grad}\left(\Pi + \frac{v^2}{2}\right) = 0; \tag{5}$$

$$\frac{\partial \Pi}{\partial t} + (\operatorname{grad}\Pi, \vec{v}) + c^2(\rho)\operatorname{div}\vec{v} = 0, \tag{6}$$

where $\vec{\Omega} = \operatorname{rot}\vec{v}$; $c^2 = \frac{dp}{d\rho}$ is squared velocity of sound.

Equation (6) is obtained from continuity equation multiplying it by

$$\frac{c^2}{\rho} = \frac{1}{\rho}\frac{dp}{d\rho} = \frac{d\Pi}{d\rho}.$$

The field of velocities $\vec{v}$ and the potential of pressure Π may be represented as a sum:

$$\vec{v} = \vec{v}_0 + \vec{v}'; \qquad \Pi = \Pi_0 + \Pi',$$

where $\vec{v}_0$ and Π_0 correspond to the main flow (undisturbed), and $\vec{v}'$ and Π' are small disturbances of elements, caused by the sound wave.

Upon writing down the equation of hydrodynamics for the field of disturbances $\vec{v}_0$ and Π' and making use of the hypothesis (2) one obtains, after discarding the squares and products of the small quantities $\vec{v}'$ and Π', the following linear system:

$$\frac{\partial \vec{v}'}{\partial t} + [\vec{\Omega}_0, \vec{v}'] + [\operatorname{rot}\vec{v}', \vec{v}_0] + \operatorname{grad}[\vec{v}_0\vec{v}' + \Pi'] = 0; \tag{7}$$

$$\frac{\partial \Pi'}{\partial t} + (\operatorname{grad}\Pi', \vec{v}_0) + (\operatorname{grad}\Pi_0, \vec{v}') + c_0^2 \operatorname{div}\vec{v}' = 0, \tag{8}$$

where

$$c_0^2 = \left(\frac{dp}{d\rho}\right)_{\rho=\rho_0}.$$

It is well known that in the case of an eddying flow the acoustic velocity $\vec{v}'$ is not a potential vector (1). We shall look for a solution for $\vec{v}'$ in the following form:

$$\frac{\partial \vec{v}'}{\partial t} = \operatorname{grad}\frac{\partial \varphi}{\partial t} + [\operatorname{grad}\varphi, \Omega_0], \tag{9}$$

where φ is an auxiliary scalar function — a «quasi-potential» of the sound wave.

If the main flow is a potential flow, i. e. $\Omega_0 = 0$, then the acoustical field is a potential field, and the quasi-potential passes into the usual potential of the sound wave.

Substituting in the main equation of hydrodynamics (1) the expression of $\vec{v}'$ according to (9) and omitting small terms of the second order, one obtains an integrable equation for φ

$$\operatorname{grad}\left(\vec{v}_0\operatorname{grad}\varphi + \Pi' + \frac{\partial \varphi}{\partial t}\right) = 0. \tag{10}$$

After this equation is integrated and the constant of integration introduced into the value of the function φ, one obtains the first equation of acoustics for a moving medium

$$D_t\varphi = -\Pi', \tag{11}$$

where $D_t = \frac{\partial}{\partial t} + (\vec{v}_0 \nabla)$ is the operator of the full derivative.

The second equation of acoustics is obtained from continuity equation (8) by means of equation (9):

$$\frac{\partial \Pi'}{\partial t} + (\operatorname{grad}\Pi', \vec{v}_0) + (\operatorname{grad}\Pi_0, \operatorname{grad}\varphi) +$$

$$+ \left(\operatorname{grad}\Pi_0, \int [\operatorname{grad}\varphi, \Omega_0]\,dt\right) + c^2\left(\Delta\varphi + \int [\operatorname{grad}\varphi, \Delta\vec{v}]\,dt\right) = 0. \tag{12}$$

Differentiating with respect to time and omitting the small term

$$(\operatorname{grad}\Pi_0 [\operatorname{grad}\varphi, \Omega_0]),$$

we ultimately get

$$D_t\left(\frac{\partial \Pi'}{\partial t}\right) = -c^2\Delta\left(\frac{\partial \varphi}{\partial t}\right) - \left(\operatorname{grad}\Pi_0, \operatorname{grad}\frac{\partial \varphi}{\partial t}\right) - c^2(\operatorname{grad}\varphi, \Delta\vec{v}). \tag{13}$$

If vorticity is constant, the system obtained passes into the following:

$$D_t\varphi = -\Pi' \tag{14}$$

$$D_t\Pi' = -(\operatorname{grad}\Pi_0, \operatorname{grad}\varphi) - c^2\Delta\varphi, \tag{15}$$

which coincides with the equations derived by N. N. Andreev.

It is seen from equation (13) that for a flow with a variable vorticity a correction term of, generally speaking, first order of smallness, depending upon the derivatives of the flow rot $\vec{v}$, has to be introduced in Andreev's equation. This term can only be neglected when the dimensionless vorticity is much less than the dimensionless velocity of the flow $\vec{u}$, i. e. when the non-uniformity of the velocity field of the main flow is much greater than the length of the acoustic wave. This is the case on transition from wave acoustics to geometrical acoustics.

From equations (11) and (13) the potential of pressure Π' can be eliminated and the result will be the equations containing only one unknown function φ:

$$D_t^2\left(\frac{\partial \varphi}{\partial t}\right) = c^2\Delta\left(\frac{\partial \varphi}{\partial t}\right) + \left(\operatorname{grad}\Pi_0, \operatorname{grad}\frac{\partial \varphi}{\partial t}\right) +$$

$$+ c^2(\Delta\vec{v}_0, \operatorname{grad}\varphi) = 0. \tag{16}$$

In a particular case, when $\Delta\vec{v}_0 = 0$, the last term of equation (16) disappears and, after integration with respect to time, one arrives at the following equation:

$$D_t^2\varphi = c^2\Delta\varphi + (\operatorname{grad}\Pi_0, \operatorname{grad}\varphi),$$

which, as can easily be verified, coincides with the respective equation of N. N. Andreev.

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TECHNICAL PHYSICS

RADIATION RECEIVER WITH REDUCED SENSITIVITY TO THE POSITION OF THE SOURCE

By N. A. DOBROTIN and I. M. FRANK

(Communicated by S. I. Wawilow, Member of the Academy, 9. I. 1943)

In a number of cases the accuracy achieved in measuring a flux of radiant energy within a given solid angle depends upon the precision with which the position of the source of radiation is given with respect to the receiver. Such is the case, for instance, when non-point sources are compared, or when the position of the source in space (for example, of a luminous gas column) cannot be fixed exactly. Similar difficulty, perhaps even to a greater degree than for light rays, arises when an exact measurement of the intensity of gamma-rays emitted by radioactive preparations is attempted. Radioactive sources of γ-rays frequently differ from one another considerably in form, and this is bound to affect the results of measurements, because their distance from the ionization chamber cannot be made as large as to be incomparable with their dimensions.

The authors have encountered a similar difficulty when developing a method, whereby the difference in the thickness of metallic tube walls might be determined from the absorption of γ-rays*. The conditions of the problem required that the difference in thickness be measured within several hundredths of a millimeter, while the source of γ-rays could not be fixed exactly. The centre of gravity of the radioactive preparation was liable to shift within one millimeter. It is easy to see that the use of a usual ionization chamber under such conditions would be impossible. Indeed, supposing, for instance, the absorption coefficient of γ-rays per 1 cm of thickness to be $\mu = 0.3$, we get a change of intensity, caused by a thickness of $d = 0.001$ cm, equal to $\Delta I_d = 310^{-4} I$. At the same time, a shifting of the centre of gravity of the radioactive preparation of $\Delta r = 0.1$ cm results, when the distance from the chamber is $r = 50$ cm, in an error of $\Delta I_r = \frac{2\Delta r}{r} I = 410^{-3} I$, which considerably exceeds the measured value.

Thus, in order to solve this or a similar problem, it is necessary to have a chamber in which the current would be determined by the intensity of the radiation source and, within certain limits, independent of its position.

The construction of a chamber, fulfilling these requirements, was first suggested by A. Piccard and L. Meylan (1). Their method is based on the following. Use is made of a flat chamber of so large dimensions as to cover the radiation of the preparation measured over an angle of nearly 2π. The whole front wall of the chamber is covered by a flat, rather thick layer of lead, so that the rays falling obliquely at the edges of the chamber are practically entirely absorbed.

---

* This work was carried out in collaboration with A. I. Avdeenko, O. N. Vavilov und V. A. Zuckerman, and will be published elsewhere.

Thus, the γ-rays penetrating into the chamber are confined within a certain solid angle, determined neither by the dimensions of the chamber nor by the position of the source, but rather by that limit angle, at which they are still capable of penetrating through lead in appreciable quantities. When lead is sufficiently thick, this angle is smaller than that subtended by the chamber, and, consequently, the possible displacement of the source will not significantly affect the ionization current. Thus, when the thickness of the filter is 2 cm Pb + 0.9 cm Fe and the surface area of the chamber $S = 1$ m², a displacement of the radium preparation away from the front wall by as much as 11 cm changes the current, according to Piccard and Meylan, by only 1%. Piccard and Meylan's method may be applied also to ordinary light rays, if a photocell of sufficiently large dimensions covered by a flat «gray» light filter is made use of.

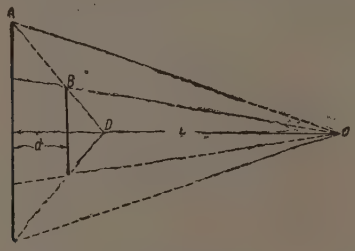

Fig. 1a

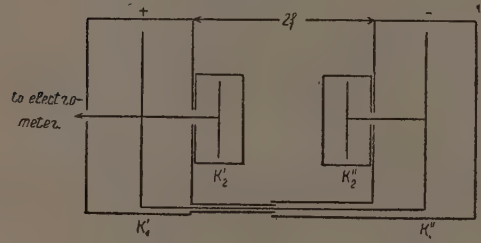

Fig. 1b

It suffers, however, from the disadvantage that either the apparatus should have a very large size or the lead filter a considerable thickness, and the latter circumstance cannot but greatly weaken the radiation. The weight of a lead filter for absorbing γ-rays is very great in all cases. Besides, in applying this method to γ-rays, the current depends not only upon the energy, but upon the spectrum of the radiation as well. A source with a more penetrating spectrum, the energy of radiation being the same, gives a greater current than a source with strongly absorbed radiation.

It is possible, however, to construct a receiver free of all these shortcomings. If between the source C and the receiver A (Fig. 1a), at a certain distance in front of the receiver, a screen B (absorbing radiation considerably and having its area smaller than that of the receiver A) is placed, then with the change of the distance between the source and receiver, the solid angle subtended by the receiver at the source and the solid angle formed by the cone of the shadow will change at a different rate, and these changes may compensate each other.

We shall show that with a certain position of the source, such a compensation must necessarily take place. Indeed, if the distance d between the receiver and the screen is small as compared with the distance r between the source and receiver, then with the change of r the registered energy will change in the same way, as if the screen was placed close to the receiver. Therefore, at large values of r the energy falling on the receiver will increase with the decrease of the distance. On the other hand, when the distances are sufficiently small, the cone of the shadow will begin with a decrease of r to widen at such a high rate that the registered energy will decrease. When the source will reach point D, the shadow will cover all the receiver, i. e. the amount of energy falling on it will decrease down to zero (it is assumed that the screen absorbs radiation entirely).

Thus, the variation of the registered energy, as a function of r, may be represented by a curve with a maximum. Close to the maximum the dependence on r will, evidently, be slight.

Curve *a* (Fig. 2, *a*), showing the dependence of the value of the ionization current upon the distance between the source of γ-rays and the ionization chamber, refers to the case when, close to the front wall of a chamber having a depth of 18.5 cm and a 18.5 × 14.5 cm front wall area, a lead screen 7 × 7 cm in area and 3 cm in thickness is placed. The distance (in centimeters) between the radioactive preparation and the front wall of the chamber is plotted as abscissa, and the value of ionization current (in arbitrary units) — as ordinate. As is seen from Fig. 2, *a*, this relation may be represented as a curve with a maximum, the change of the distance of the radioactive preparation from 6.5 to 8.5 cm leaving the ionization current practically unchanged (the change being less than 1%).

Curve *b* shows the dependence of the ionization current upon the distance for the same chamber, but without the lead filter. In this case the change of the distance to the radioactive preparation from 6.5 to 8.5 cm changes the value of the ionization current by more than 20%. If the radioactive preparation is removed 18 cm away from the chamber (and the current in the chamber made thereby equal to the maximum current in the presence of the above-mentioned screen), then a change of the distance by 2 cm will change the value of the current by 15%.

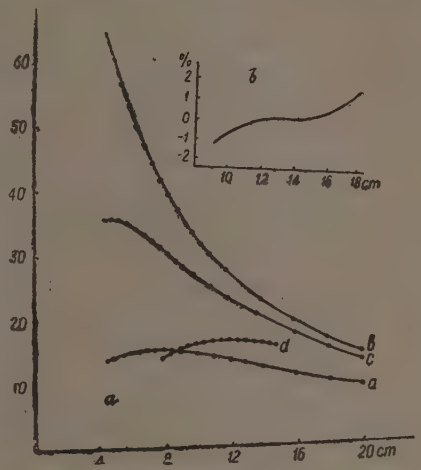

Fig. 2, *a* and *b*

Curve *c* has been obtained when at the front wall of the chamber there was a lead screen of smaller size, namely 4 × 4 cm and the same thickness of 3 cm. As was to be expected, the value of the ionization current increased, as compared to that obtained with the larger screen (curve *a*), and the position of the maximum shifted almost close to the front wall of the chamber.

It is obvious that this very method of compensation of the dependence of the registered energy on the distance may be applied in a similar manner not only to γ-rays and X-rays, but to the ordinary light rays as well.

A shortcoming of the method considered is the dependence of the maximum position on the angular distribution of radiation.

In the case of γ-rays it is not difficult to eliminate this drawback. Instead of a lead screen, a small ionization chamber K_2' (Fig. 1b) switched on opposite to the main chamber K_1' may be placed. Although γ-rays from the source C, having passed through K_2', will reach the main chamber K_1' and will give rise to current in it (i. e. in reality there will be no shadow), still the current will be either wholly or partly compensated by the current of the chamber K_2'. It is obvious that the substitution of the screen by such a «counter»-chamber opens up additional possibilities of arbitrary regulation not only of the surface of the chamber, but of its volume as well. First of all, the counter-chamber K_2' can be made of such a size that, with the optimal position of the source of γ-rays, it will just close the solid angle subtended by the main chamber. In this case, if the absorption of γ-rays in K_2' be neglected, the calculation of its dimensions is particularly simple.

We shall show that the compensation of the dependence of the value of the current on the distance will be achieved if the counter-chamber be made in a form similar to the main one, and the source of γ-rays be placed in the centre of similitude. Let the dependence of I_1 (the value of the ionization current of the main chamber) on r_1 (the distance between

the source and a certain point of the chamber) be represented by the function $I_1 = f(\vec{r_1})$. For the counter-chamber, on account of its similarity, the dependence of the current on the distance will be represented by the same function $f(r)$ on the condition that the scale of the distance is diminished k times, k being the coefficient of similarity. Here, for a similar position of the source of γ-rays with respect to the chambers, the absolute value of the ionization current in the counter-chamber would be k times smaller than in the main one. Consequently, for the counter-chamber wer have $I_2 = \frac{1}{k} f(\vec{kr_2})$. Thus, the total current, when the two chambers are switched on opposite to each other, will be $I = I_1 - I_2 = f_1(\vec{r_1}) - \frac{1}{k} f(\vec{kr_2})$.

Hence it follows that the condition $\frac{dI}{dr} = 0$ will be fulfilled if $\vec{r_1} = \vec{kr_2}$, i. e. if the source of γ-rays is in the centre of similitude.

In the case of the counter-chamber, the dependence of the ionization current on the position of the source of γ-rays is wholly similar to the one obtained when the lead screen is present. This may be seen from curve d (Fig. 2, a), obtained when a chamber, 18.5 by 14.5 cm in size, 12.5 cm in depth, had another chamber similar in form, but $2\frac{1}{4}$ times smaller in size, switched on in front and opposite to it.

The position of the maximum in the case of such a counter-chamber, evidently, does not depend on the angular distribution of radiation. The dependence on the spectrum of radiation is here also practically absent.

In the case of exact measurement of γ-rays, the compensational method is frequently used. The method of the counter-chamber is particularly efficient, if for compensation one may use the radiation of the same radiation source, i. e. not when different sources are compared, but when, for instance, the influence of different absorbers on radiation is determined. In this case the source of γ-rays is placed between two similar sets of chambers K_1', K_2' and K_1'', K_2'' (Fig. 1b), consisting of the main and the counter-chamber. Both of the sets are switched on opposite to each other. In such a system the dependence of the current on the position of the source is very slight. Indeed, the value of the ionization current in each of the sets has its maximum value, when the source is at a certain distance f from the surface of the chambers. Let us place both of the sets at a distance of $2f$ from each other, with the source placed in the centre between them. Then the currents in each of the chamber sets will be maximum in value, but opposite in sign, and will compensate each other fully. If now the source be shifted in one direction towards one of the chambers, then the absolute value of the current in each of the sets will somewhat decrease, and this difference will either equal zero, or will change to a very slight degree. It is evident that this change will be smaller than for each of the chamber sets separately.

The dependence of the difference current on the position of the source (the distance from one of the chambers in centimeters) thus obtained may be seen from Fig. 2, b (the size of the main chambers is 29.5×29.5 cm, their depth 2.5 cm, the counter-chambers are 3 times smaller than the main chambers). As may be seen from Fig. 2, b, the shifting of the radioactive preparation from 12 to 15 cm changes the difference current less than by 0.1 % with respect to the value of the maximum current of one of the chamber sets.

By means of such a system it is possible to measure with greater accuracy the γ-rays absorbed in a very thin absorber, or to compare two absorbers but slightly differing from each other, without having to worry about exact fixation of the position of the radiation source.

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GEOPHYSICS

EARTH SURFACE UNDER ULTRA-VIOLET AND INTEGRAL RADIATION OF THE SKY

By N. N. KALITIN

(Communicated by A. A. Grigoriev, Member of the Academy, 22.XII.1942)

The scattered radiation of the sky has its spectral composition depending largely on the state of the sky with regard to cloudiness. If the sky is cloudless, the maximum of radiation corresponds to about 4200 Å; in the case of overcast sky it lies in the neighbourhood of 7300 Å. For cloudless sky the position of the maximum will vary according to the altitude of the sun above the horizon and the transparency of the atmosphere. The position of the maximum is also affected by the degree and form of cloudiness; if the latter increases, the maximum will be shifted toward longer waves. The more rapid the movement of clouds, the sharper will be the changes in the spectral composition of the scattered radiation of the atmosphere and its intensity.

The spectral irradiation of the earth surface with the scattered radiation of the atmosphere will thus depend, both qualitatively and quantitatively, on a number of meteorological factors. It cannot be properly studied, unless special investigation is carried out under natural conditions.

In the present article the results are summed up of a study of alterations in the ultra-violet and integral flow of atmosphere scattered radiation, as depending on meteorological conditions, mainly on cloudiness.

Method. The intensity of the integral flow of scattered radiation was as always measured by means of Yanishevsky's pyranometer, and that of the integral flow of ultra-violet radiation was measured with the aid of a sulphur-selenium photocell designed by K. G. Trofimov. This photocell has the advantage of involving no temperature coefficient and being not liable to fatigue; covered with a filter, it allows to measure the ultra-violet radiation within 3000 — 4000 Å. The measurements were carried out in the country-side, i. e. under the most favourable conditions for this kind of investigation. The pyranometer and the photocell were placed side by side on an open field; they were screened from the sun if the sky was cloudless, and indications of the galvanometers of the two set-ups were registered simultaneously every 30 seconds. A series of observations was usually continued for 25 minutes. Within August-September 1942, 50 series of such parallel observations were made under varying conditions of cloudiness.

The treatment of the observations made consisted in computing the ratio between the intensities of the ultra-violet (uv) flow of radiation, and of the integral (i) flow for every pair of simultaneous readings. It was thus made possible from the variation of this ratio (uv/i) to judge of the variation of the ultra-violet portion of radiation in the total flow of radiation.

Fig. 1 shows some typical curves bringing out the ratio uv/i. Time (25 min.) is plotted as abscissa; the ratio uv/i, as ordinate. The figures to the right side of the curves give the average height of the sun during the observation; the figures on the left side indicate the number of observations. The three upper curves refer to cloudless sky. As is evident from Fig. 1, even with a quite clear sky, the intensity of the upper violet portion of scattered radiation is liable to change considerably. For record *9* the mean ratio uv/i is 2.18; for record *35* it is 3.60, though the measurements have been made practically at the same altitude of the sun above the horizon. The remark attached by the observer to the former record is: «sky very pale, halo 4» (by a five-point scale); to the latter record: «sky deep-blue, no halo».

It will be obvious that, according to the transparency of the atmosphere, the ultra-violet part of the integral flow of radiation can, even for a cloudless sky, vary greatly, increasing as the atmosphere becomes more transparent, and conversely.

The latter conclusion is corroborated by the values of the general coefficient of transparency, as obtained from the measured intensity of solar radiation. Thus, for record *9* the coefficient of transparency was 0.680; in the case of record *35* it amounted to 0.708.

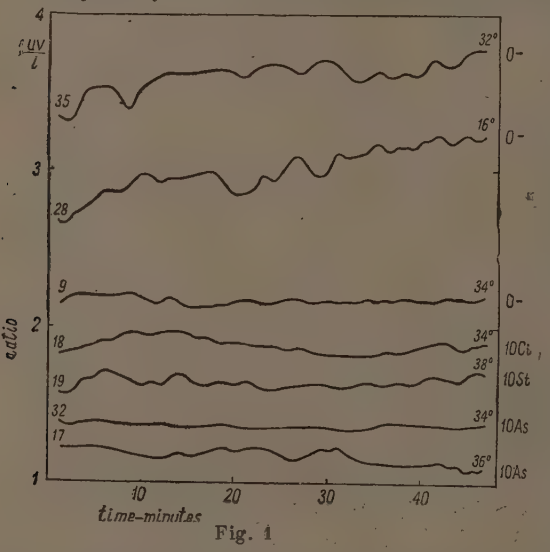

Fig. 1

Curve *28* shows a marked increase in the value of uv/i in the course of observation; this is due to a systematical increase of the ultra-violet part of the scattered radiation, owing to the increase of the height of the sun within this interval.

The four lower curves show the value of uv/i and bring out its variation when the sky is completely covered with clouds of different form.

Curve *18* refers to a cirri (*Ci*) covered sky; here the value of uv/i was 1.91 as an average, i. e. rather near to the value obtained in record *9* (cloudless sky with poorly transparent atmosphere), because with this type of clouds there is a considerable space of blue sky, and the clouds themselves are of small density. Curve *19* refers to the stratus-form of cloud (*St*); the average value of uv/i is 1.66, i. e. less than in the previous case; the reason for this is that there is no blue sky with this form of cloud.

Curve *32* brings out the state of affairs when the sky is covered with alto-stratus clouds (*As*); the value of uv/i is still less —1.38; clouds of this type form over the sky an unbroken cover of a pale whitish colour.

Finally, curve *17* relates to alto-cumuli (*Ac*). This type of cloud is generally characterized by a considerable number of lacunas, but in this case the clouds were very dense, and the blue specks were nearly absent. This accounts for the value of uv/i being as small as 1.18 on the average. The higher value of this ratio in the case of observation *19* than in *17*, in spite of a continuous layer of clouds without openings, may apparently be explained by the fact that *St* were very thin in this case. This conclusion gives ground to hope that such an indirect method can be used to appraise

the thickness of a continuous layer of clouds. Further work is necessary in this direction.

That the rate of flow from the ultra-violet part of the spectrum is greatly dependent upon cloudiness, is obvious from observation *31*, registered on September 18, when the average elevation of the sun was 33°. These results are represented graphically in Fig. 2. In the lower part of the figure the curves give the rate of the integral flow of radiation (i) and of its ultra-violet portion (uv) directly, as recorded by the galvanometer. In the upper part the curve uv/i is plotted. An analysis of the run of the curve shows that at the beginning of the observations the value of the uv/i ratio was 1.28; it amounted to 2.70 in 16 minutes, i. e. increased more than twice, and afterwards went down, so that by the end of observations it was equal to 1.65.

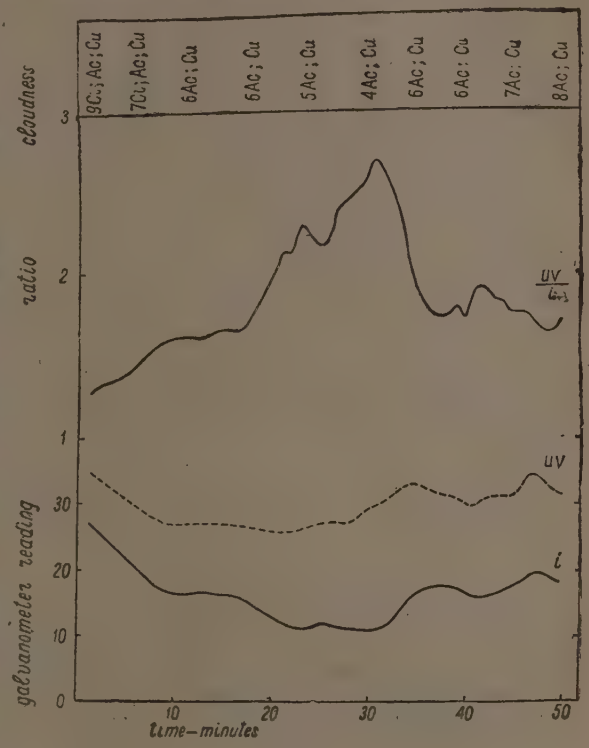

Fig. 2

Comparing the course of the upper curve with the two lower curves, one arrives at the following conclusions. At the start of observation the scattered radiation, both the integral and the ultra-violet, show a decrease, the two curves run downwards, the decrease of the integral radiation being continuous for 16 munutes; during this interval the integral radiation dropped down to 59% and then began to rise. The ultra-violet radiation was also decreasing from the outset, but only during 10 minutes; it decreased by 26% and after that commenced to rise. This is because cloudiness at the start of observations was (as is seen from the topmost part of the figure where cloudiness is indicated) practically continuous (9 points) and then was steadily decreasing, the blue specks of sky appearing in increasing number. This went to increase the ultra-violet portion of the radiation. On that account, the decrease of the uv curve is less that that of the i curve, and from the 11th minute onwards the uv curve even begins to rise, whereas the i curve continues to decline.

The position of the maximum on the uv/i curve corresponds to the minimum of cloudiness (4 points). Afterwards the cloudiness starts increasing, which is attended by a backward run of all curves. This instance shows in a representative manner how great can be the variation in the ratio between the ultra-violet and the integrai radiation depending on the value of cloudiness. In this case the change was more than by 100% during the short period of observation (25 minutes).

This result is of great practical importance mainly for the problems of air-survey (exposure, adequate choice of filters). As the value of uv/i depends

mainly on the ratio between the areas of overcast and cloudless sky and upon the position of the clouds upon the sky face (the region of the zenith being especially active in this respect), it is only natural that the rate of variation of the magnitude of *uv/i* is a function of the velocity of wind at the height of the clouds. The fluctuations of this magnitude are particularly great when separate cloud-formations pass over the blue sky across the region of the zenith, or else, in the case of a continuous cloud-cover, when blue openings appear and disappear in that region. An illustrative confirmation of this statement is furnished by Fig. 3, where the course of variation of the same elements as in Fig. 2 is shown. During observarion the cloudiness (sundered cumuli—*FrCu*) changed from 6 to 8 points, and the clouds passed the zenith very fast, becausé the velocity of the wind at their height was 15 m per second. This rapid movement of clouds was accompanied by alterations of the ratio *uv/i*, which were considerable in magnitude and followed rapidly one after another. There were moments when this ratio changed by 100% in 4 minutes.

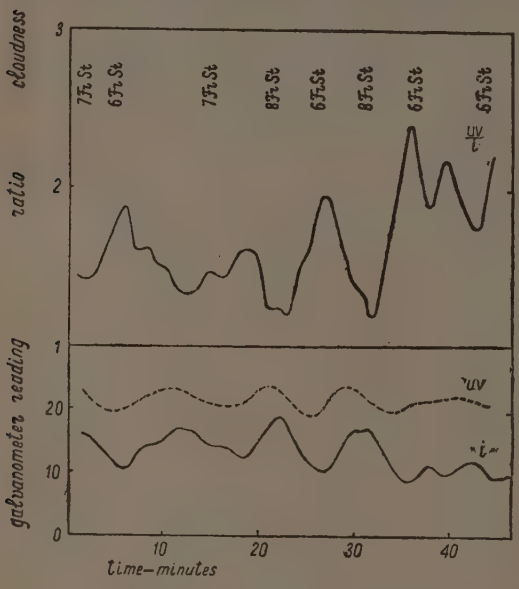

Fig. 3

Still greater interest attaches to a similar work in which the spectrum will be divided into several separate parts; this is not difficult, as we have to-day a great variety of photocells, thermocouples and filters at our disposal. There is not a shadow of doubt that such a work, accomplished for more limited parts of the spectrum, will give a more valuable material for studying the radiation reaching the earth surface from different parts of the spectrum and under different meteorological conditions. These data are necessary for observations made from aeroplanes (air-survey, choice of contrasting filters etc.).

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CHEMISTRY

CRYSTALLIZATION VOLUMES OF THE QUATERNARY RECIPROCAL SYSTEM Na, K || F, Br, I

By N. S. DOMBROVSKAYA

(Communicated by V. G. Chlopin, Member of the Academy, 16.XII. 1942)

This system completes the investigation of the exterior faceting of the quinquenary reciprocal system Na, K || F, Cl, Br [1–6]. In the simplest type when no solid solutions are formed, the volume of the constitution diagram of the quaternary reciprocal system of the type $A, B \| X, Y, Z$, having the form of a trihedral prism, is divided into 6 crystallization volumes.

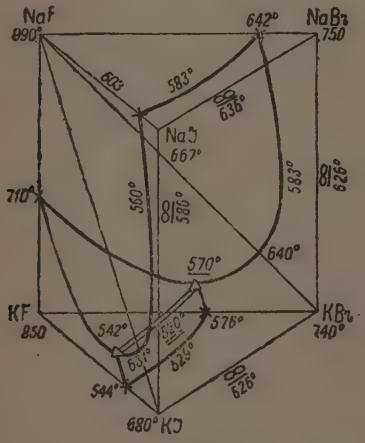

Fig. 1

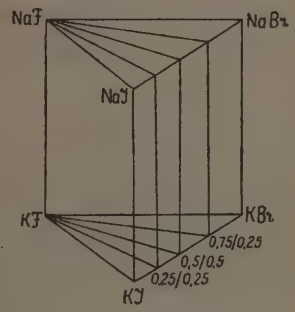

Fig. 2. Sections through prism

In our system, owing to the formation of continuous solid solutions between the bromides and the iodides of sodium and potassium, the number of crystallization volumes is reduced to three: NaF, K, F and (Na, K) (Br, I) (Fig. 1).

The exterior facets of the quaternary reciprocal system are three ternary reciprocal systems:

1) Na, K || F, Br (7);
2) Na, K || F, I (8);
3) Na, K || Br, I (9)

and two ternary systems:

4) Na | F, Br, I;
5) K || F, Br, I.

1) Na, K ‖ F, Br (7). In agreement with the magnitude of the conditional thermochemical effect, which equals +11.6 cal., the reaction is shifted towards the formation of NaF + KBr, which forms a stable pair dividing the system into two ternary ones: a) NaF — KBr — KF with an eutectic point at 570°C and 7.5% NaF + 56% KBr + 36.5% KF; b) NaF — KBr — NaBr with a minimum on the curve of joint crystallization at 583° and 17% NaF + 32% KBr + 51% NaBr, appearing instead of the ternary eutectic, owing to the formation of continuous solid solutions (Na, K) Br.

2) Na, K ‖ F, I (8). The arbitrary thermochemical effect equals +13.1 cal. The irreversibility of the reciprocal system is increased compared with the previous system. This is reflected in the appearance of singular elements upon the diagram; the isotherms below 750° are intersected at a sharp angle when passing through the stable diagonal NaF — KI, which divides the system into two ternary ones: a) NaF — KI — — KF with an eutectic point at 542° and 64% KI + 31% KF + 5% NaF, and b) NaF — KI — NaI with a minimum at 560° and 57% NaI + 35% KI + 8% NaF on the curve of the joint crystallization of the continuous solutions (Na, K) I and NaF.

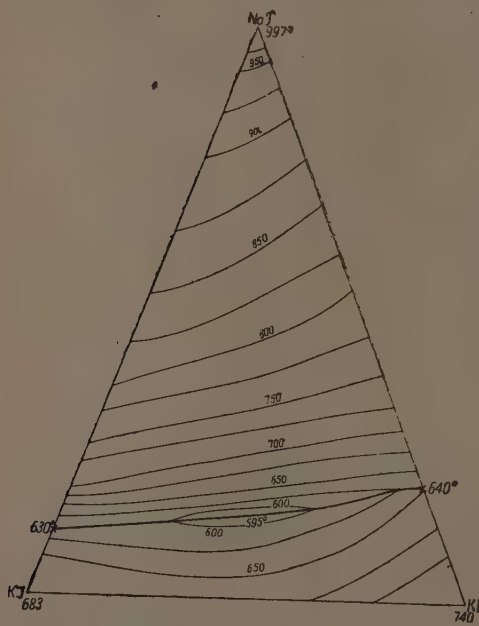

Fig. 3. Stable diagonal section

The system should be referred to as a transitional type between the irreversible reciprocal system and singular ones.

3) Na, K ‖ Br, I (9). All the four salts form continuous solid solutions with a minimum on the crystallization surface at 548° and 45% KI + 43% NaBr + 12% NaI. The thermal effect (arbitrary) of the metathetic reaction equals 1.5 cal. towards the components NaBr + KI. This reciprocal system can have no considerable influence upon the direction of the metathetic reaction in the quaternary system, but stipulates the appearance of a crystallization volume mutual for the four salts.

4) Ternary system: Na ‖ F, Br, I (V. P. Radisčev).

5) Ternary system: K ‖ F, Br, I (V. P. Radisčev).

Each of the ternary systems has only two fields: 1) of the fluoride and 2) of continuous solid solutions (Br, I).

Upon the line of joint crystallization there are minima in the first system at 583° and 27.5% NaBr + 54% NaI + 18% NaF, and in the second one at 529° and 32% KF + 25% KBr + 43% KI. The minima are shifted towards the binary system «fluoride — iodide». Within the prism three «book» cross-sections have been studied, according to Fig. 2, as well as the diagonal ones.

The quaternary reciprocal system Na, K ‖ F, Br, I is intersected by a stable diagonal planar cross-section NaF — KBr — KI into two main parts:

1) a tetrahedron of the quaternary system NaF — KF — KBr — KI and 2) a pyramid NaF — KBr — KI — NaBr — NaI.

The stable diagonal cross-section NaF—KBr—KI. The lateral sides of the isosceles triangle are stable cross-sections NaF—KBr and NaF—KI. The third side is closed by the system KBr—KI with continuous solid solutions. Upon the curve of joint crystallization we have a minimum at 595° and at a composition 14% NaF+43% KBr+43% KI (Fig. 3).

The metastable diagonal cross-section NaI—NaBr—KF is sharply different from the stable cross-section NaF—KBr—KI. The diagram (Fig. 4) consists of three fields: 1) KF, 2) continuous solid solutions and 3) field of NaF, very characteristic by its configuration and the disposition of isotherms.

The fields KI and NaF are intersected along the line of joint crystallization of these two phases with a minimum at 650°. The fields of NaF and of Na (Br, I) are also intersected along the line of joint crystallization with a minimum at 546°. In the field NaF there is a high ridge along the line *AB* with the highest temperature at point *A*.

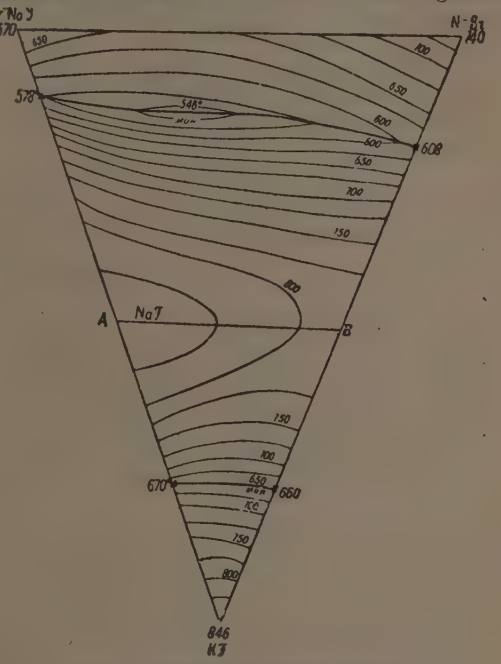

Fig. 4. Metastable diagonal section

Tetrahedron of the quaternary system NaF—KF—KBr—KI. There are three crystallization volumes in the tetrahedron: 1) the largest volume belongs to NaF, the less soluble component; 2) the volume of KF, which in the quaternary system also does not depass the borders of the tetrahedron, and 3) the volume of continuous solid solutions (Na, K) (Br, I). The quaternary point is absent, there is a curve of the crystallization of three solid phases with a minimum at 520° and 4.5% NaF+33.5% KF+31% KBr+31% KI, situated in the vicinity of 50% of the cross-section.

Pyramid NaF—KBr—NaBr—KI—NaI. All the lateral facets of the pyramid are ternary systems, in which there is one field of NaF and a second one of continuous solid solutions (Na, K) Br. Na (Br, I), (Na, K) I and K (Br, I). In all the lateral ternary systems there are minima upon the curves of the joint crystallization of two solid phases. As a result of such a faceting within the pyramid there are only two volumes: 1) NaF and 2) continuous solid solutions (Na, K) (Br, I).

On the surface of joint crystallization of these two phases we find one minimum point at 528°, situated not far away from the minimum of the reciprocal system Na, K | Br, I, near 50% of the cross-section.

Conclusions

1. The constitution diagram of the quaternary reciprocal system Na, K | F, Br, I separates into three crystallization volumes: 1) NaF, the largest in volume; this points at the lowest solubility and at a shift of the reaction towards its formation; 2) KF and 3) continuous solid solutions of sodium and potassium bromides and iodides.

2) The curve of the co-existence of three solid phases — the intersection of the three crystallization volumes has a minimum at 520° and a composition 4.5% NaF + 31% KBr + 31% KI + 33.5% KF.

3) The metathetic reaction in the reciprocal system is shifted towards the formation of NaF + KI in the first line, and of NaF — KBr in the second. Accordingly, the most stable ternary diagonal cross-section is NaF — KBr — KI, and second place with reference to stability is occupied by the cross-section NaF — KI — NaBr.

4) The stable cross-section NaF — KBr — KI divides the constitution prism into: a) a tetrahedron NaF — KF — KBr — KI, and b) a pyramid NaF — KBr — NaBr — NaI — KI.

5) Within the prism we have a gradual transition from the lateral reciprocal system Na, K || F, Br to another lateral system Na, K || F, I; accordingly, the space of the prism separates into three crystallization volumes.

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GEOCHEMISTRY

CARBONIFEROUS BRINES OF THE POLASNA-KRASNOKAMSK ANTICLINE

By A. M. KUZNETZOV and S. N. NOVIKOV

(Communicated by W. I. Vernadsky, Member of the Academy, 22.VII.1942)

On drilling for oil in the Middle and Lower Carboniferous rocks* of the Kama region ([1–3]) hydrosulphuric brines of considerable practical and theoretical interest have been encountered. In the present paper the purpose of the authors is to give a general characteristic of the present composition of these waters and to point out some of their features, which may prove to be useful as correlates.

The complex of Carboniferous rocks is made up by limestones and dolomites with a varying content of a highly dispersive terrigeneous substance and of calcium sulphate. In productive and coal-bearing series the terrigeneous material is preponderant over carbonates. The gypsum and anhydrite scattered in the rocks have a different degree of dispersness.

The content of $CaSO_4$ in the bed is 2% on the average, being very considerable in the upper layers of the Carboniferous and extremely small in the sandstones of the coal-bearing series. The average content of NaCl is 0.4%; of organic matter, 0.2% in carbonate rocks and 0.5% in clays. This complex of deposits is permeated with calcium chloride brines of high concentration. Typical brines of six horizons have been investigated by us: 1) sulphide brines (No. 1) in the top of Middle Carboniferous from a depth of 710—730 m; 2) edge waters—brines (Nos. 2 and 3) of the productive series from a depth of 1000—1100 m.**; 3) sub-oil sulphide brines from a depth of 980—1060 m (Nos. 4. 5 and 6); 4) sulphide brines (No. 7) of the Visean stage from a depth of 1180 m; 5) brines (Nos. 8, 9, 10 and 11) of the coal-bearing series from a depth of 1240—1350 m; 6) brines (No. 12) of the Tournean stage from a depth of 1385 m.

The static level of waters in the productive series is established at a depth of 50—70 m from the surface, and the hydrostatic pressure amounts to 117 atm.

The Kama region is characterized by a high geothermal gradient, i. e. by a slow increase of temperature with depth. From a depth of 100 m the geothermal step is 83.5 m. The temperature of these waters grows, as is shown by distribution curves (see figure), from 13.5 to 21.5° C.

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* The waters of the Upper Carboniferous have not been investigated.

** The depth of occurrence of these waters increases, according to the immersion of the rocks, in the direction from Krasnokamsk to Polasna.

Table 1

Nos*	pH	Pressure 20° C	In grams per kilogram of brine											Total g-equ.	[Na] / [Cl]	[NH₄] / [Br] + [I]
			Na	K	NH_4	Mg	Ca	Cl	Br	I	SO_4	(SO_4)**	HCO_3	H_2S		
1	6.2	1.179	82.134	0.556	0.142	1.223	5.440	139.268	0.270	0.009	1.415	not determ	0.300	0.450	7.930	0.91	2.28
2	6.1	1.180	56.657	0.737	0.188	5.680	19.408	138.023	0.871	0.021	0.460	0.466	0.031	+	7.827	0.63	0.94
3	not determ	1.173	53.097	0.879	0.158	6.410	19.612	135.733	0.693	0.017	0.417	0.421	0.030	+	7.691	0.62	0.99
4	6.4	1.172	61.002	1.082	0.156	3.750	15.990	133.922	0.614	0.017	0.474	0.550	0.051	0.140	7.590	0.70	1.10
5	6.3	1.172	60.971	1.046	0.156	3.552	16.246	133.619	0.590	0.017	0.540	0.620	0.065	0.082	7.576	0.70	1.15
6	6.3	1.172	61.403	1.263	0.165	3.571	15.619	133.573	0.515	0.015	0.438	0.527	0.104	0.056	7.570	0.71	1.39
7	6.1	1.174	62.652	1.689	0.131	4.255	14.562	135.722	0.507	0.017	0.681	0.700	0.147	0.116	7.698	0.71	1.12
8	not determ	1.180	61.966	0.862	0.101	3.473	16.309	138.624	0.505	0.013	0.220	0.478	0.081	—	7.843	0.71	0.87
9	6.1	1.167	60.123	0.953	0.106	3.348	15.253	130.134	0.499	0.011	0.204	0.618	0.040	—	7.360	0.71	0.92
10	6.0	1.177	64.791	0.834	0.100	3.472	15.881	138.634	0.465	0.011	0.224	0.485	0.067	—	7.842	0.72	0.93
11	6.2	1.174	63.733	0.899	0.098	3.471	15.597	136.576	0.459	0.012	0.221	0.510	0.043	—	7.724	0.72	0.93
12	6.2	1.176	62.468	1.019	0.117	3.956	15.688	136.020	0.474	0.009	0.570	0.596	0.061	—	7.709	0.71	1.08

* 1—Krasnokamsk, well No. 11, 12.XII.39, depth 720 m. 2—Polasna, well No. 2, 27.IV.39, depth 1057—1095 m. 3—Severokamsk, well No. 5, 25.VI.39, depth 1030—1050 m. 4—Krasnokamsk, well No. 62, 28.X.40, depth 937—990 m. 5—Krasnokamsk, well No. 66, 22.X.40, depth 1054—1060 m. 6—Krasnokamsk, well No. 100, 17.IV.41, depth 992—998 m. 7—Krasnokamsk, well No. 82, 25.VII.40, depth 1184—1188 m. 8—Severokamsk, well No. 4, 11.III.39, depth 1324—1325.5 m. 9—Severokamsk, well No. 10, 11.XII.40, depth 1347—1348 m. 10—Krasnokamsk, well No. 82, 1.XII.40, depth 1252—1252.7 m. 11—Krasnokamsk, well No. 104, 29.VI.40, depth 1243—1244.3 m. 12—Severokamsk, well No. 10, 30.XI.40, depth 1370—1385.5 m.

** Concentration of SO_4 upon saturation with gypsum (5 g $CaSO_4 \cdot 2H_2O$ per 1 kg of solution).

The tabulated (Table 1*) composition of the brines points to a considerable

Temperature distribution in the thickness of Permian and Carboniferous rocks of the Kama region: *1*—well 5 and *2*—well 1 Severokamsk; *3*—well 2 V.-Chusovskie Gorodki; *4*—well 17 and *5*—well 1 Krasnokamsk.

accumulation of bromine, iodine and ammonium, especially in the waters of the productive series. Besides, the edge waters are enriched

* The analyses of the brines were made by us in 1941. H_2S was estimated in fresh samples from wells: the aliquots used in the estimation of K, Mg, Ca and Cl did not weigh more than 10 g; SO_4, Br, I, NH_4, H_2S, HCO_3 were determined in brine volume ranging from 25 to 100 cm^3; Na was determined as the remainder left after subtraction. The samples were taken at the end of a long pumping following the perforation of the

with magnesium and calcium, and the increased accumulation of these elements is reflected in the clay-dolomite complex of the inclosing rocks. Somewhat apart stand the brines of the coal-bearing series; they are poor in sulphates because of the low content of $CaSO_4$ in the rocks of this series.

Experimentally we have found that the brines, except those of the Carboniferous series, are nearly saturated with $CaSO_4$. In the edge waters 1.0% of $CaSO_4$ (as calculated to the natural concentration of this salt in the brine) may be dissolved in addition; to sub-oil waters 17.7% can be added; to the Visean brines, 2.8%; to the brines of the coal-bearing series, 121%; and to those of the Tournean stage, 4.5%. So low a saturation of the brines with $CaSO_4$ may be accounted for by them having lost gases on ascending to the surface. The same reason appears to lie behind the fact that they are not saturated with sodium chloride to the limit. Thus, in 1 kg of brines 3, 9, 13 at 18° C there could still be dissolved 50.6, 42.1, 43.9 g of NaCl, respectively. Yet, this may as well be due to the low content of halite in the solid phase.

Judgment about the gas composition of the investigated brines can be based on the analysis of a sample of sub-oil water, taken at a depth of 900 m by means of a vacuum-apparatus. Estimation of gases has shown that the brines of this horizon belong to the nitrogen methanic type highly saturated with gases. The gas content amounts to 294 cm^3 per litre; total pressure, 70.2 atm; the composition is as follows:

	CH_4	C_2H_6	C_3H_6 and more	N_2 and rare	A, Kr, X	He,Ne	A 100 : N_2
cm^3 per l	113.5	9.1	0.9	170.5	0.256	Increased	0.15
pressure in atm. . .	16.2	0.7		53.3	0.026	»	—

The ratio of argon to nitrogen testifies to a tenfold enrichment of the brine with biogenic nitrogen (4). The amount and pressure of argon points to the fact that the water was mineralized in the process of migration through rocks, rather than to its relict character.

The Carboniferous brines have close values of ionic power, ranging from 4.11 to 4.63 and all show a very similar molar concentration, varying within 6.84—7.73. The ratio of $[Ca]:[Mg]=1.86-2.85$ and that of $[NH_4]:[Br+I]=0.87-1.39$ are not liable to considerable variation either, except for brine 1, in which the latter ratio is equal to 2.28.

In silt the concentration of iodine is known to be proportional to the amount of organic matter and to the dispersion of the silt (5); the same is probably true of bromine (6,7). This explains the appearance of these atoms in brines. Nitrogen gets into bottom deposits along with organic matter (8,9) which afterwards is decomposed, and also by way of adsorption of NH_4^+ from the water covering the deposits. The concentration of ammonium in the bottom part of the sea with pronounced reduction processes has been reported in literature (10). The position of the ion NH_4^+ in the lyotropic series is, in accordance with its radius, between potassium and rubidium (11). The content of potassium in sea water is 2.5% of the amount received by the sea (12), and sea muds are enriched with this element (13). In the clays of the productive series (wells 62 and 66) the content of ammonia was found to vary from 0.015 to 0.019%. This explains the occurrence of NH_4^+ in the brines.

The concentration of H_2S was recorded in the waters of top-portion of the Carboniferous as 0.45 g per 1000 g; in sub-oil waters, 0.16. In the edge waters concentration of H_2S was found to be extremely low, and no H_2S at all was detected in the waters of the coal-bearing series, or at the bottom of

column, or else from the interval of the well at a specified depth. An adequate storing of the samples was secured. Brine 9 was slightly diluted. In taking the samples we received help from S. S. Zhirnov, geologist.

the Carboniferous. The cause of these differences may lie in the physiological equilibrium of the solution being disturbed ([14]) by the accumulation of Ca and Mg in the process of physical-chemical reactions. It may therefore be supposed that the biogenic reaction process of sulphates in edge waters, where there are 21 atoms of Ca and 10 atoms of Mg to every 100 atoms of Na, has come to an end. Sub-oil sulphate brines contain malodorous products, which are probably organic surphurous compounds. This may be accounted for by the varying content of sulphur in the oil, which in the productive series increases from the top to the bottom layers. On the distillation of the oil from the lower layers hydrogen sulphide, mercaptanes and elementary sulphur evolve in large quantities *.

In Table 2 some constants are given which may be useful as correlates. Moreover, the water from the top of the Middle Carboniferous is distinguishable by its content of bromine and hydrogen sulphide; the water of the coal-bearing series may be distinguished by the quantity of $CaSO_4$ it is capable to absorb in addition, and the feature peculiar to the waters from the top-portion of the oil-bearing series is their high concentration of Ca and Mg.

Table 2

Nos.	$\frac{g\ Na}{g\ Cl}$	$g\ SO_4$	$\frac{g\ Ca}{g\ SO_4}$	Ions per 100 [Na]	
				[Ca]	[SO_4]
1	0.91	29.5	9.2	3.8	0.41
2	0.63	9.1	106.0	21.2	0.20
3	0.70	9.5	82.0	15.0	0.18
4	0.71	14.2	51.2	13.5	0.26
5	0.72	4.5	174.0	14.1	0.08
6	0.71	11.9	66.0	14.4	0.22

The salt statics of the Carboniferous brines is no constant one, although these are no mobile brines on account of their considerable viscosity. The variation of their composition is by way of enrichment with salts, by exchange of cations with the solid phase; besides, it is complicated by the products of biogenic processes ([15]). Magnesium and calcium are more easily displaced by sodium in the rocks endowed with strong powers of exchange. This is evidenced by the difference in the concentration of Ca and Mg in the brines found in the rocks of the carbonate and carbonate-clayey complex (brines 1 and 2, 3). The authors were not able to trace the composition of the Carboniferous waters in the areas lying close to the surface, and of the places of denudation.

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* Personal information received from N. D. Gritzev, chief of the Petroleum group of the Krasnokamsk laboratory.

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GEOLOGY

DISTRIBUTION BOUNDARIES OF TIN-TUNGSTEN AND GOLD ORES IN EAST KAZAKHSTAN

By I. A. PREOBRAZHENSKY

(Communicated by A. E. Fersman, Member of the Academy, 6.XII.1942)

In East Kazakhstan there are a number of intrusions running in nearly parallel rows but dating back to different times. «Kalba» and «Monastyr» granites, coarse, moderately and fine-grained granites have not all been formed at quite the same date and they are not bearing the same metals.

The group of more ancient and more basic rocks of the Zmeinogorsk complex is situated parallel to the groups of Kalbanian and Monastyr granites. Their metal ore wealth is of distinctly different character. With them gold-sulphide ores and not tin-tungsten ores are associated (contrary to the case of Kalbanian granites). In Southern Altai (Narym) the zone of compression, which on a map by V. P. Nekhoroshev proceeds from the mouth of river Narym south-eastward, is roughly the boundary between the two types of mineralization. However, simultaneously formed intrusions may also differ as to the metals they bear, and the tectonic line is no strict boundary between the different types.

From slick tests it may be inferred that the boundary of tin and tungsten mineralization approaches river Irtysh from SE and, running somewhat below the point at which river Saya-su is emptying into it, crosses the Kalbanian granite of the main massive. These granites continue their course eastward from the compression zone. They are indicated along river Putishna where neither cassiterite nor scheelite have been found in slicks. The direction of geological structures defines the direction of metalliferous strips and these strips in Southern Altai appear from slick tests to be rather sharply delimitated.

It may be supposed that the boundary between the different ore types after crossing the river Irtysh below the issue of river Saya-su again comes near to the Irtysh, above the issue of its tributary Voilochevka. NE of this boundary no tin-tungsten ore should be expected. Recent surveying, carried out in 1942, seems to corroborate this conclusion, to which we have arrived by extrapolation.

Along the watershed of the rivers flowing down the Kalbanian range in the north-easterly and south-westerly directions another boundary of mineralization types may roughly be traced. In South Kalba from Kuludjun to Kizyl-su scarcely any cassiterite or scheelite is encountered in the slicks from river alluvium. But they have been found to contain gold. The placers of Mynchunkur are very near to this boundary and their feeding zones also comprise gold-bearing areas. In the slicks from Mynchunkur one finds therefore gold, as well as silver and electrum. The alluvium of river Kainda contains cassiterite and scheelite, and the boundary of tin-tungsten mineralization

should therefore be drawn west of the Kainda. In the lower course of river Bukon cassiterite has been found, while it is not indicated in the upper course of that river. Probably, the boundary of gold mineralization runs across the lower course of river Kuludjun and turns westward, crossing the middle course of the river Bukon. It may further be supposed to turn north-westward, should there be no alteration in the direction of the ore strips.

There is ground to surmise the existence on the south-west of another boundary of tin-tungsten mineralization, on the outside of which there is another strip of gold ores. In Tarbagatai cassiterite has been reported by Sinitzyn in the slicks from alluvium of rivers flowing in a northerly (NE) direction. But further south, along the Ters-airyk, gold placers occur. The second point of the supposed boundary is the mount Kandygatai near the station Zharma,

Distribution boundaries of tin-tungsten and gold ores in East Kazakhstan

Turkmen-Siberian railway. Here N. F. Anikeeva has stated the presence of scheelite in the alluvium slicks of the Erinbulak and of cassiterite in the slicks from the Ters-airyk. South of Kandygatai, in the region investigated by D. S. Korzhinsky, gold placers are located.

No data are available for determining the boundary of tin-tungsten mineralization between Kandygatai and Tarbagatai (it may run north-weast or south-west of the Sandyk-tas and the Kush-murun mountains). According to V. P. Nekhoroshev, there is no tin or tungsten in Saur; the mineralization boundary may be drawn north of Saur, going round its north-western end, the range Monrak.

There is molybdenum ore in Saur. It has been reported from the Batpak-bulak, a left-hand tributary of the Kaldjir. Molybdenum ores have also been found near Sandyk-tas. Here, too, they may possibly border upon tin-tungsten ores, and the boundary between the different kinds of ore is likely to run from the Ters-airyk (Tarbagatai) to Kandygatai along the northern and north-eastern slopes of the Tarbagatai and across Sandyk-tas. In the western part of Tarbagatan no slick tests have been made (according to Nekhoroshev).

To the north-west of Kandygatai and Mynchunkur the boundary of tin-tungsten mineralization is uncertain. It is possible that the mountains of

Aldzhan, Arkat, Urda-tau and Dogolan lie on its continuation. This is partly confirmed by the discovery of molybdenum ores in the mt. Degelen. The possible position of the mountain Arkalyk and Semey-tau is in the gold ore-band, corresponding to that within which the Kuludjun is located. Along the right bank of the river Irtysh the boundary of tin-tungsten ores runs probably close to the river. According to S. D. Konchakov, scheelite and cassiterite still occur, although in small quantities, in the slick from rivers on the right bank of the river Irtysh, near the issue of the Ulanka. From that point on the boundary goes to the north of Vavilon deposit.

Thus, the following metal-bearing strips may be outlined:

1) Irtysh (right bank), gold-bearing with sulphide ores;

2) Kalbanian, from Takura to Ube; tin and tungsten;

3) Kuludjun, from Kuludjun to Semey-tau (?); gold-bearing;

4) Kandygatai, from Pokrovka (on the Kandy-su) to Kandygatai; tin and tungsten;

5) Ters-airyk, from Ters-airyk (Tarbagatai) to mt. Degelen; gold and molybdenum.

The first three of these strips have formerly been indicated by Elisseev, Nekhoroshev and Trofimov under the following names: 1) polymetallic ore belt, or Rudnyi Altai; 2) tungsten-tin belt of Kalba—Narym; 3) gold-bearing belt of Kalba. On the south coast near Batpak-bulak, the boundary of the Kalba belt may possibly turn to the south and, crossing the Black Irtysh, unite, north of the Ters-airyk, with the boundary running north of the Tarbagatai.

It is of interest to point out that the molybdenum deposits form a strip along the boundary of tin-tungsten and gold ore: Batpak-bulak—Saur—Sandyktas—Degelen. The question arises, May not the molybdenum deposits, situated north-east of Irtysh-Turgusun, and others, be in a similar position?

The conjectures as to the places, through which run the boundaries of tin and tungsten mineralization, lead to some practical conclusions concerning the direction in which the search for new industrial deposits of tin and tungsten should be conducted. Particular attention must be paid to those places where the boundary of tin and tungsten occurrence has already been determined with an accuracy sufficient to start the prospecting work, namely to Tarbagatai and Kandygatai (Zharma). The prospecting should be attended with the inspection and investigation of the country rocks, mainly, of the intrusive rocks of the acid series and of their accessory minerals and derivatives. This is necessary for the preliminary determination of the areas within which the search for tin and tungsten is to be started.

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ENTOMOLOGY

ANDRENA (ANDRENELLA) NANAEFORMIS NOSK. AS AN ELEMENT OF THE WOOD AND STEPPE FAUNA *(HYMENOPTERA, APOIDEA)*

By V. V. POPOV

(Communicated by L. A. Orbeli, Member of the Academy, 8. I. 1943)

As compared to the *Apoidea* of other countries, those of Europe are the most thoroughly investigated; they cannot, however, be considered sufficiently well known. New species are being described every year; the zoogeographical and ecological character of most species still remains uncertain, occasionally disputed or wrongly interpreted. Many species that are of rare occurrence in the west are frequently met within the eastern part of this country, which corresponds to their main area of distribution. It stands to reason that the character of the areas of distribution of these species and the degree of their assignment to a given belt of vegetation can neither be safely established nor correctly interpreted, unless data are available for this country as a whole.

To these species belongs *Andrenella nanaeformis* Nosk., which was described after a single female by the well-known zoologist, J. Noskiewicz (1) in 1925 from the environs of Lwow. It has later been found by A. Lebedev at Kiev and Lubotin (2). R. Kunze and J. Noskiewicz (3) interpreted this species as a probable ponthian element (in the sense of Holdhaus) of the fauna of Western Podolia.

The genus *Andrena* which embraces more than 2000 species has an almost world-wide distribution, but it is most widespread in the Holarctic regions. The subgenus *Andrenella* consists of more than 50 species within the boundaries of the Palearctic region only; a considerable number of these species have a very wide range of distribution; some are strictly confined to the Mediterranean or Central Asiatic subregions.

It seemed therefore scarcely probable that *A. nanaeformis* Nosk. would be referrable to some definite zone of vegetation, or would have a clear-cut area of distribution. The study of a rather abundant material collected by the Zoological Institute of the Academy of Sciences of the USSR and by the Zoological Institute of the Moscow University, as well as the finding of heretofore unknown males of this species, made us change our idea about the subject.

Aside from the localities that have previously been reported, the species is known from the following localities of this country (from west to east): Kirovograd, Belopesotzkoy (Moscow Dept.), Borisovka (Kursk Dept.), Kursk, Gremjachka (Rjazan Dept.), Voronezh, Podoskley near Tambov, Pjatigorsk, Uralsk, Spasskoe (Chkalov Dept.), Borovoe (Kustanay Dept.) [*A. nana* Nyl. (5)], Biysk, Onguday and Verkhniy Uymon (Altai region). The character of distribution of *A. nanaeformis* Nosk. leaves no

doubt that the species is definitely linked up with the wood and steppe zone. It is noteworthy that all the places south to the line of the wood and steppe region, where the species has been reported (viz. Pjatigorsk and Uralsk), represent isolated spots of wood and steppe, their fauna invariably containing wood and steppe elements. In South Siberia patches of wood and steppe are known to extend far to the east. It may safely be asserted that the spots of Altai, where the species was found, coincide with small wood-steppe areas that are not plotted on vegetation maps. Thus, *Bombus (Confusobombus) paradoxus* D. T. has been reported from Ridderovsk (Altai) that lays beyond the wood and steppe zone. According to Skorikov [6], this bumble-bee is a typical inhabitant of wood and steppe regions. *A. nanaeformis* thus seems to be a rare example of *Apoidea*, being strictly confined to the wood and steppe zone. To my knowledge, it is the first case among *Apoidea* aside from the instance cited above (*B. paradoxus* D. T.). This allotment of *A. nanaeformis* to the wood and steppe zone is probably underlain by a mono- or oligotrophism with respect to a definite, or some definite, melittophylous phanerogams.

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MICROBIOLOGY

CONTRIBUTION TO THE PROBLEM OF VARIATION OF LEPRA CULTURES SUBJECTED TO X-RAYING*

By Anna ZHOLKEVICH

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Leprosy stands apart among the rest of contagious diseases both on account of the extreme difficulty of isolating the lepra-causative organism in artificial growths, and because of the great variety of the microorganisms that have been described as the causative agent of this disease; these belong to the genera of corynebacteria, mycobacteria and proactinomycetes. The variety of microbic forms that are isolated in the case of leprosy found its explanation in the doctrine of the complicated developmental cycle of the organism causing leprosy as passing through a number of stages, viz. that of coccus, diphteroid, acidoresistant bacillus, and proactinomyces.

One of those who founded the doctrine of the complex developmental cycle of the causative organism of leprosy was W. I. Kedrovsky. In 1900 Kedrovsky isolated a diphteroid culture of lepra which, when injected to rabbits, provoked in the latter leprosy. In the organism of the animals the microbes were found to pass into acidoresistant state. From one of the infected rabbits Kedrovsky isolated two virulent growths, an acidoresistant, and an acidosusceptible one. Kedrovsky failed to preserve the latter, while the former soon lost its virulent properties. Kedrovsky tried to transfer his acidoresistant culture into an acidosusceptible condition, but his attempts proved a failure.

I supposed that Kedrovsky's culture, like many other lepra cultures which do but encumber museums of living cultures, may in fact be the causative organism of leprosy, the bacillus of Hansen. The origination of these cultures could be imagined in the following way. At the period of struggle between macro- and microorganisms, the microbe of leprosy is being affected by various factors. In the process of variation it splits off a number of modifications and mutants; some of these, viz., those which approach the properties of saprophytes, prove able to develop on laboratory nutrient media. The frequency of such mutations is very low, and this is why experimentors have but rarely succeeded in isolating acidoresistant lepra cultures. In order to raise the frequency of origination of lepra cultures, and with the purpose of studying the course of variation of lepra microbacteria, I found it expedient to test the mutogenic action of X-rays.

* Delivered at a conference of the Institute of Microbiology of the Academy of Sciences of the USSR, on June 2nd, 1940.

Method. The culture is purified by repeated passages through a single colony. From a fortnight-old culture there is prepared an emulsion, containing 500 million microbic bodies per 1 cm^3. As sensitizer there is added an aqueous emulsion of chaulmoogra-oil, so as to obtain a suspension, containing chaulmoogra-oil at the ratio 1:1000 and 1:10000. The microbe emulsion is put into sterile boxes closed with a double layer of paper, and exposed to unfiltered X-rays at a dose from 100 to 10000 r. For the cultures of Kedrovsky and Clegg the optimal doses proved those ranging between 1800 and 3000 r, for Duval's cultures, doses from 100 to 500 r. Sowing was made into Petri dishes containing Gohn's medium; the dishes were sealed with paraffin.

Under the action of X-rays, the cultures of Kedrovsky, Clegg, Duval and Bayon could be dissociated into *R*- and *S*-forms. Clegg and Bayon's cultures gave typical *R*-forms, those of Kedrovsky and Duval gave folded forms with a central papilla. Along with smooth *S*-forms, one could observe in these cultures the appearance of mucoid forms (*M*).

Both the smooth and folded colonies of Kedrovsky's *Mycobacteria* contained an admixture of acidosusceptible cells. Some of the colonies of the *S*-type consisted of individuals inclined to ramification. From these were grafted the so-called «ramiferous X-ray races» of Kedrovsky's *Mycobacteria*, among which, mostly in young culture, ramiferous individuals are met. Very rarely (no more than 1:20000—30000 colonies) one happens to meet folded colonies with central papilla, consisiting of acidosusceptible grains and granular diphteroids, which occasionally contain acidoresistant inclusions. From one of such colonies there was grafted the acidosusceptible culture No. 30/2, which was similar to the diphteroid culture described by Kedrovsky (1).

In subcultures grown on Gohn's medium this culture gives a growth in the form of small lustrous colonies. Is achromogeneous and gives no growth on potato or meat-peptone media. Develops after some 24—48 hours at 37° C. When drying is liable to give in the upper parts of the growth a reversion in the shape of isolated beautiful acidoresistant streptobacilli.

The diphteroid culture No. 30/2 was exposed for the second time to soft X-rays without a sensitizer (2000 r), and dissociated into *R*- and *S*- forms. Some of the colonies of the *S*-type have been found to contain an admixture of acidoresistant individuals. In one of the Petri dishes there was discovered an *S*-type colony of bright brick-orange colour; it consisted of beautiful granular rods endowed with acid- and alcoholresistant properties. The chromogeneous culture No. 241 that has been grafted from it differs from Kedrovsky's culture not only by its bright coloration, but by the rate of development as well: it gives growth towards the third day, at 37° C, while Kedrovsky's culture develops not until the 8th day. Culture No. 241 is more heat-resistant; it withstands heating at 60°C during 20 minutes. In our experiments Kedrovsky's cultures perished under these conditions.

By applying the same method (combined action of aqueous emulsion of chaulmoogra-oil and X-rays) I have ohtained cyanophyl X-ray races from cultures of *Mycobact. leprae* Clegg, *Mycobact. leprae* Duval and *Mycobact. leprae* Bayon.

From an acidoresistant culture of *Mycobact. leprae* Clegg there was obtained the achromogeneous X-ray race No. 50/6, which was found similar to the achromogeneous X-ray race No. 30/2, obtained by me from the culture of Kedrovsky's *Mycobacteria*. Upon Gohn's medium it gave towards the 2nd or 3rd day a growth in the form of small drop-like colonies. The colonies are made up of cyanophyl grains and granular formations, arranged in chains. Multiplication is not only by way of division, but by formation of globular individuals («gonidiangia»), as well; the contents of the latter divides into several granules and is discharged. When drying

or repeatedly exposed to X-rays without sensitizer, culture No. 50/6 shows the development of separate beautiful streptobacilli, endowed with acidoresistive properties.

From a culture of *Mycobact. leprae* Duval there was obtained a cyanophyl X-ray race inclined to spontaneous ramification. When X-rayed again, it was found to contain isolated acidoresistant bulbiform individuals and acidoresistant streptobacilli.

The cultures of *Mycobacteria leprae* Bayon proved resistant to X-ray treatment. In order to make it produce mutations, it was found necessary to use 6-month-old growths, to subject the latter for 7 days to starvation in distilled water at 37°C, to apply a 10-fold dose of sensitizer (water emulsion of chaulmoogra-oil in a dilution 1 : 1000), and after this only to expose the culture to X-rays at a dose of 3300 r and more.

The cyanophyl culture obtained shows a great morphological likeness with the diphteroid culture described by Bayon.

Conclusions

1. Under the combined action of aqueous emulsion of chaulmoogra-oil and X-rays, *Mycobacteria leprae* Kedrovsky, Clegg, Bayon and Duval have been dissociated into *R*- and *S*-forms.

2. X-ray races have been obtained differing from the original cultures in the rate of development, shape and colour of the colonies, morphological structure of cells, and their acid and alcohol resistance. The possibility of existence of Kedrovsky's, Clegg's, Duval's and Bayon's mycobacteria in the form not only of acidoresistant bacilli, but of acidosusceptible cocci and diphteroids, has been proved.

3. The process of reversion from cocci into bacilli, and from an acidosusceptible state into an acidoresistant, can be brought out by means of repeated X-raying of the cultures or by a passage through animals (see communication 2).

4. By applying the mutogenic action of X-rays to the study of the process of variation of the lepra cultures known to us, it is made possible experimentally to create new races, resembling those that have been reported by various authors from different parts of the world as being the causative organism of leprosy, viz. acidoresistant and acidosusceptible races, achromogeneous and pigmented races, ramiferous and such as consist of cocci and diphteroids.

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MICROBIOLOGY

A PURIFIED PROTEIN PREPARATION OF WINTER WHEAT MOSAIC VIRUS

By K. S. SUKHOV

(Communicated by L. A. Orbeli, Member of the Academy, 27. XI. 1942)

In 1940 near Moscow the author observed a mosaic disease in wheat which he found to be identical with the one reported by Zazhurilo and Sitnikova from the province of Voronezh ([1], [2]).

Experiments have shown that this mosaic disease, like that from Voronezh, is not transmitted by the juice, but is carried from plant to plant by an insect — the *Deltocephalus striatus* L.

In accordance with the data of the above-mentioned authors I failed to detect any virus inclusions in living affected cells. Yet the investigation of the affected tissues in solution of acids and acid salts at pH = 4 has disclosed the formation of numerous needle-like crystals. Similar crystals are obtained by extracting from mosaic leaves their juice in the presence of acid solutions ([3]).

As no crystals had been found under equal conditions in either the extract from, or in the tissues of, sound wheat leaves, I naturally arrived at the conclusion that the substance of these crystals was the protein of the mosaic virus.

A similar substance was found to accumulate in the intestine of insects fed upon an affected wheat. There it could only be detected after the intestine was placed in acid solutions at pH = 4.

Upon the examination of histological thin-sections of mosaic wheat leaves treated with acid fixatives I discovered needle-like inclusions in the affected cells.

Also a sharp histotropy of the virus became manifest, since it is only in the parenchymal cells immediately surrounding the vascular bundles that I observed the accumulation of crystals. In the same cells a decomposition of plastids, reduction of their size and sometimes complete disappearance were noticeable. Further away from the vascular bundles the cells contained normally developed plastids. Here there were no crystals.

In this particular the mosaic of winter wheat differs sharply from «zakuklivanie», which is another virus affection of cereals. In the latter case virus inclusions are encountered in all tissues of an affected plant.

Taking into account the peculiarities of crystal formation in the tissues and in the expressed juice, I set to work on obtaining a purified preparation of the crystals. Mosaic leaves of wheat cut to small bits were placed in a porcelain mortar, and upon the addition of a little amount of

0.1% solution of sodium carbonate ground to a paste. The extract, expressed through gauze, was filtered through Seitz's asbestos discs. To the transparent filtrate a small quantity of a decinormal solution of hydrochloric acid was carefully added down the walls of the test-tube. At the interface between the filtrate and the acid solution a white film was formed, which was found under the microscope to consist of needle-like crystals. After the formation of the film the test-tube was shaken several times and the whole mass of the filtrate became rapidly turbid. Further shaking of the test-tube made the film form clouds of a silky lustre. The pH of the solution was about 4.

After a short centrifuging a rather dense precipitete was obtained, all of which was made up by needle-like crystals and coloured by pigments to a brownish hue. The colour of the preparation interfered with a biuret reaction, and so I had recourse to microchemical reaction. Under the microscope the accumulations of crystals after treatment with solutions of blue vitriol and caustic alkali were observed to fuse into a mass which took on a violet colour.

Thus was brought to light the protein nature of the needle-like crystals forming in the extract of a mosaic wheat.

The mass formation of protein crystals from mosaic leaves, in face of their complete absence in the sound control, is a strong evidence in favour of the identity of the substance of these crystals with the virus of the wheat mosaic. Of course, my conclusions are not made without taking into consideration that in order to place beyond doubt the identity of the virus with its protein preparation the infectuousness of the latter has to be proved. And this I have not yet been able to do in a final manner because of the difficulties experienced in working on viruses that are not transmitted artificially with the juice.

The mosaic of winter wheat is a typical representative of yellows. It is not transmitted with the juice, but only by the agency of *Deltocephalus striatus*. And in the organism of the latter it goes through a long incubation period.

So far it has not been proved for the viruses of this type that they are a protein substance, like the virus of tobacco mosaic and several other viruses. Viewed in this light the result obtained appears to be of particular importance, since it brings out the general nature of phytopathogenic viruses of the mosaic group and the yellows.

Later (in the autumn of 1941) Sukhov, Vovk and Alexeeva by using the same method purified the virus of another yellow — the «zakuklivanie» of oats (unpublished). This virus in not transmitted with the juice either and is communicated to the plant by an insect carrier, the *Delphax striatella* Fall. (3).

Data on Protein Crystals of the Virus of Zakuklivanie and the Virus of Winter Wheat Mosaic

Name of virus	Presence of virus inclusions in living cells	Presence of needle-like crystals on maceration of mosaic leaves in water	Formation of needle-like crystals on maceration of leaves in a *n*/10 solution of HCl	Preservation of purified preparation of virus	
				pH = 4	pH = 5
Zakuklivanie	+	+	—	—	+
Winter wheat mosaic	—	—*	+	+	—

* Crystals are very rarely detected in water upon the maceration of dying-away leaves from affected wheat. Only leaves that have not lost vitality must be taken for analysis.

when it passes an incubation period of 6 to 24 days (4). Comparing certain particulars of the virus proteins in these two yellows, one may distinguish some typical difference which I have already found to be of diagnostic value for the discrimination between the two infections (see the table).

To conclude it must be emphasized that this is a single report in literature of cases when a virus protein has been detected morphologically in the organism of the carrier insect with which it is bound organically.

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HELMINTHOLOGY

THE TREND OF EVOLUTION OF THE NEMATODES OF THE FAMILY *ACUARIIDAE*

By A. A. SOBOLEV

(Communicated by K. I. Skrjabin, Member of the Academy, 4. XI. 1942)

The nematodes of the family *Acuariidae* Seurat, 1913, parasitic of birds, are characterized by a very high degree of adaptive specialization. The author makes an attempt to retrace the course of evolution of these nematodes, introducing at the same time more precision into their taxonomy. We adopt here the structure of this family in the form in which it has been formulated by K. I. Skrjabin (1).

1. Subfamily *Acuariidae* Raill., Henry et Sisoff, 1942

Among the four subfamilies of the family *Acuariidae* the largest is the subfamily *Acuariinae*. The original, least specialized genus of this subfamily is undoubtedly the genus *Acuaria* Bremser, 1811. Its representatives are characterized by the presence of disconnected cordons which are the only organ of fixation inherent to this genus. The appearance of a connexion between the cordons, which by isolating the anterior end of the parasite contributes to its steadier fixation to the wall of the alimentary canal of the bird, is a character of the one group of genera, directly originating from *Acuaria*. These are: *Syncuaria* Gilbert, 1927, and *Chevreuxia* Seurat, 1918.

The latter of the two represents a lateral ramification that branched-off from *Syncuaria* and acquired a peculiar adaptation in the form of a wide cuticular collar. This character is met in none of the genera entering this family.

In these genera the cervical papillae are but slightly expressed, and may scarcely play any essential rôle in the fixation of the parasite.

The genus *Dispharynx* Raill., Henry et Sisoff, 1912, stands as it were midway between the genus *Acuaria* and the genera *Syncuaria* and *Chevreuxia*, in so far as the cordons are here directed onwards without forming a connexion.

The genus *Syncuaria* gave rise to the most specialized group of genera, which are characterized by the presence of strongly developed organs of fixation (except for *Chevreuxia*), by sharp indented elements that penetrate the tissue of the host. Two branches may be differentiated here. The one is represented by the genera *Synhimanthus* Railliet, Henry et Sisoff, 1912, *Cosmocephalus* Molin, 1858, and *Sexansocara* Sobolev et Soudarikov, 1939.

The last genus which is supplied, like *Synhimanthus*, with tridented cer-

vical papillae and a peculiar bent at the basis of the cordons, like *Cosmocephalus*, displays at the same time an exceptionally complicated ornamentation of its indented cordons, possessing the most perfect fixation apparatus among all the genera of the subfamily (in which the cordons are the chief fixation organs).

The second branch incloses the peculiar genus *Pectinospirura* Wehr., 1933. This genus has up to recently been represented by a single species, *P. argentata* Wehr., 1933. We have found a representative of this genus in *Terekia cinerea* Güld., 1774; owing to the considerable size of the cervical papillae, which are armed with 33 indentations each, we give it the rank of an independent species, *Pectinospirura multidentata* n. sp.

A character that is common to both these phylogenetic branches is the presence of cordons joint laterally. The divergency that has arisen between the two branches is due to a very curious dependence of evolutionary morphological nature. The genus *Sexansocara* and partly some of the genera that are nearest to it, show an disconnexion of the anterior end of their bodies in the shape of a mushroom-cap; in *Sexansocara* the posterior edge of the cordons forms practically a continuous line. In these nematodes the cervical papillae, though indented, occupy quite smal areas around the worm's body.

In *Pectinospirura* the disconnexion of the anterior end is, unlike this, effected by the cervical papillae. In *P. multidentata* the width of both cervical papillae makes up 79.4% of the circumference of the worm's body. Cordons of this type do not differ as to their development from those in the genus *Syncuaria*.

A different trend of development, starting from *Acuaria*, is represented by a group of genera possessing shortened cordons.

We face here two phylogenetic branches: *Aviculariella* Wehr., 1931, and *Rusguniella* Seurat, 1919, on the one hand, and *Antennocara* Wassilkowa, 1926, on the other. The latter genus was established by Wassilkowa ([3]) in 1926.

Solonitzin ([4]) gave in 1928 the description of a form found by him in *Tringa* sp., having defined it as *Antennocara skrjabini* Wassilkowa, 1926. While treating the material collected from *Terekia cinerea* by the 184-th and 206-th All-Union Helminthological expeditions, these forms were found to be identical with those studied by Solonitzin and to have nothing to do with *Antennocara skrjabini*. They ought to be considered as representatives of a separate species of the genus, *Schistorophus* Raill., 1916. We suggest for this species the name of *Schistorophus cornutus* nomen novum (syn. *Antennocara skrjabini* Solonitzin, 1928, nec Wassilkowa, 1926).

The morphological peculiarities of these genera of the subfamily *Acuariinae* are directly dependent on their adaptation to the environment. They inhabit the oesophage, glandular and muscular stomach of birds. Forms, endowed with poorly developed fixation organs (the genera *Acuaria*, *Syncuaria*, *Chevreuxia*, *Cheilospirura*, *Antennocara*, *Rusguniella*), are either entirely or in an overwhelming majority of cases living under the cuticle of the muscular stomach. The representatives of the genera *Dispharynx* and *Synhimanthus* are localized in all the three sections, their most typical medium being the glandular stomach and the oesophage.

Finally, the genera with highly specialized fixation apparatuses (*Cosmocephalus*, *Sexansocara* and *Pectinospirura*) inhabit exclusively the oesophage and the glandular stomach.

2. Subfamily *Echinuriinae* Sobolev, 1941

This subfamily is characterized by the presence of longitudinal rows of cuticular spines along the sides of the body. The typical genus of this sub-

family is the least specialized genus *Echinuria* Solowiew, 1912. This genus embraces the species *E. ardeae* (Smith, Fox et White, 1908), *E. calcarata* (Molin, 1860), *E. contorta* (Molin, 1858), *E. decorata* (Cram, 1927), *E. hargilae* (Baylis et Daubney, 1923), *E. leptoptili* (Gedoelst, 1916), *E. longeornata* (Molin, 1860); all of them are deprived of spines, having only laterally connected cordons. In agreement with our interpretation of the boundaries of the genus *Echinuria*, all the above species are to be excluded from it, and classed with the genus *Syncuaria* Gilbert, 1927.

The most essential character of the genus *Skrjabinoclava* Sobolev, 1941, is the disconnexion of the cephalic part of the body, by which is limited the extent of the cordons and where do not reach the longitudinal rows of spines. We have here the same morphological trend as has been pointed out by us in the progeny of the genus *Syncuaria* in the subfamily *Acuariinae*.

Aside from the three species included by us, viz. *Skr. horrida* (Rud., 1809), *Skr. decorata* (Solonitzin, 1928) and *Skr. cincli* (Yamaguti, 1935), here belongs also the form that has been erroneously defined by Solonitzin (4) as *Ech. aculeata* (Creplin, 1825), this name being synonymous to *Skr. horrida* (Rud., 1809), as shown by Cram (5). The form described by Solonitzin has been observed by the author when dissecting *Actitis hypoleucus* L., 1758. Upon examination it has been given the rank of an independent species, characterized by the presence of unbent cordons and a cuticular swelling, that separates the cephalic part of the worm from the rest of the body. This species is given by us the name *Skr. solonitzini* nomen novum.

The genus *Skrjabinoclava* is a taxonomic group that undoubtedly isolated itself from the genus *Echinuria*. Similar environment (muscular and glandular stomach and oesophage of the birds, for the genus *Echinuria*, oesophage and glandular stomach, for the genus *Skrjabinoclava*) resulted in the convergence to what has been described by us for the subfamily *Acuariinae*.

The other phylogenetic branch of the *Echinuriinae* is made up of *Skrjabinocara* Kuraschwili, 1941, and *Seuratia* Skrjabin, 1916. These two genera approach each other, first, by having cordons markedly indented along the edges, and secondly, by their powerful tridented cervical papillae.

The close relationship between the two genera stands beyond any doubt; however, the morphological traits listed above make one assume that they have originated from some group of lower specialization, rather than from the genus *Echinuria*.

3. Subfamily *Streptocarinae* Skrj., 1941

This subfamily which includes but a single genus *Streptocara* Raill., Henry et Sisoff, 1912, is the most primitive among the subfamilies of the family *Acuariidae*, whose direct ancestors it approaches.

Conclusions

1. The phylogenetic evolution of the family *Acuariidae* started from the subfamily *Acuariinae*. The typical genus of the latter gave rise to such forms as, thanks to a powerful development of their fixation apparatus localized in the cephalic part of the parasite, adapted themselves to a new habitat (oesophage and glandular stomach of birds).

2. Owing both to a poor specialization and diversity of species, as well as to a wide range of distribution, the genus *Acuaria* itself is capable to give rise to new evolutional lines.

3. The subfamily *Echinuriinae* surpasses the subfamily *Acuariinae* in the degree of adaptation (its new morphological character is the presence of longitudinal spines). Aside from the genus *Echinuria*, it embraces such forms

that have already attained not only high perfection in their adaptation to the direct area of habitation, but became specific with regard to a definite species of the host. Thus, we never happened to meet *Skrajbinoclava decorata* in any bird except *Terekia cinerea* Güld., though the parasite is of no unfrequent occurrence. The literature furnishes no data as to this parasite being found in any other host.

4. A typical morphological trait characteristic of progressive genera of this subfamily, is the disconnexion of the anterior part of the body. The disconnexion is effected either through cordons (*Sexansocara*, *Skrjabinoclava*) or through cervical papillae (*Pectinospirura*).

5. The subfamily *Streptocarinae* represents a primitive group, approaching the original forms of the family.

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ERRATA

In the article by G. A. GRÜNBERG, this periodical, vol. XXXVII, No. 5—6

Page	Line	Instead of	Read
175	12 above	$\pm\frac{\partial\psi}{\partial s}=-\frac{\partial\bar{\varphi}}{\partial n}=$	$\pm\frac{\partial\psi}{\partial s}=\frac{\partial\bar{\varphi}}{\partial n}=$
175	15 »	$\ldots f(s)+i\int\ldots$	$\ldots f(s)\pm i\int\ldots$
177	6 »	.. differential for $\bar{\varphi}$.	... differential equation for $\bar{\varphi}$.

In the article by E. STEUERMANN, this periodical, vol. XXXVIII, No. 7

Page	Line	Instead of	Read
198	6 below	$=\frac{\pi}{\frac{A_+}{A_-}-}$	$=\frac{\pi}{\frac{A_+}{A^-}-1}$

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